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(19)

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(54) ELECTRON MULTIPLIERS

(71) We, MULLARD LIMITED, of Abacus House, 33, Gutter Lane, London E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electron multipliers and more particularly to electron multipliers of the channel plate type and methods of manufacturing same. The invention is applicable to channel plates for use in electronic imaging tube applications.

In present practice a "channel plate" is a secondary-emissive electron-multiplier device comprising a matrix in the form of a plate having a large number of elongate channels passing through its thickness, said plate having a first conductive layer on its input face and a separate second conductive layer on its output face to act respectively as input and output electrodes.

Secondary-emissive intensifier devices of this character are described, for example, in Patent Specification No. 1,064,073, No. 1,064,074, No. 1,064,076, No. 1,090,406 and No. 1,154,515, while methods of manufacture are described in Patent Specification No. 1,064,072 and No. 1,064,075.

The channel plates described in these specifications can be regarded as continuous-dynode devices in that the material of the matrix is continuous (though not necessarily uniform) in the direction of thickness, or the direction of the channels. In their operation a potential difference is applied between the two electrode layers of the matrix so as to set up an electric field to accelerate the electrons, which field channel plates, secondary-emissive multiplication takes place in the channels.

More recently, various modifications have been proposed which will be referred to as "laminated" channel plates in contrast with the conventional continuous-dynode type of channel plate. Some of these proposals hark back to an earlier proposal which appeared in 1960 when Burns and Neumann published details of a channel plate made up of a number of perforate metal layers separated from each other by layers of insulator (J. Burns and M. J. Neumann, Advances in Electronics and Electron Physics XII 1960 pages 97—111). In this and the more recent modifications the continuous matrix of the conventional channel plate structure is replaced by a stack of perforate conductive sheets or plates which are separated from each other and act as discrete dynodes i.e. dynodes which are sufficiently conductive to maintain all their exposed surfaces at the same potential (in operation a discrete dynode will normally produce only one multiplication in response to the landing of an input particle—this contrasts with the multi-hop operation of conventional continuous-dynode devices). The laminated channel plate structure which is closest to the continuous dynode type is a structure in accordance with Patent Specification No. 1,401,969 (Application No. 53371/71), wherein the matrix is formed as a laminated structure comprising alternate conductor layers and resistive separator layers wlth aligned apertures providing the channels. Since the separators are resistive, any charge accumulated thereon by the arrival of electrons will flow to the more positive adjacent conductor. Similarly, electrons will flow from the more negative adjacent conductor to replace any secondary

ERRATUM

SPECIFICATION No. 1,434,053

Page 1, Heading, (72), Inventors, *delete* MEWSON *insert* HEWSON

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This invention relates to electron multipliers and more particularly to electron multipliers of the channel plate type and methods of manufacturing same. The invention is applicable to channel plates for use in electronic imaging tube applications.

In present practice a "channel plate" is a secondary-emissive electron-multiplier device comprising a matrix in the form of a plate having a large number of elongate channels passing through its thickness, said plate having a first conductive layer on its input face and a separate second conductive layer on its output face to act respectively as input and output electrodes.

Secondary-emissive intensifier devices of this character are described, for example, in Patent Specification No. 1,064,073, No. 1,064,074, No. 1,064,076, No. 1,090,406 and No. 1,154,515, while methods of manufacture are described in Patent Specification No. 1,064,072 and No. 1,064,075.

The channel plates described in these specifications can be regarded as continuous-dynode devices in that the material of the matrix is continuous (though not necessarily uniform) in the direction of thickness, or the direction of the channels. In their operation a potential difference is applied between the two electrode layers of the matrix so as to set up an electric field to accelerate the electrons, which field establishes a potential gradient created by current flowing through resistive surfaces formed inside the channels or (if such channel surfaces are absent) through the bulk material of the matrix. As in all channel plates, secondary-emissive multiplication takes place in the channels.

More recently, various modifications have been proposed which will be referred to as "laminated" channel plates in contrast with the conventional continuous-dynode type of channel plate. Some of these proposals hark back to an earlier proposal which appeared in 1960 when Burns and Neumann published details of a channel plate made up of a number of perforate metal layers separated from each other by layers of insulator (J. Burns and M. J. Neumann, Advances in Electronics and Electron Physics XII 1960 pages 97—111). In this and the more recent modifications the continuous matrix of the conventional channel plate structure is replaced by a stack of perforate conductive sheets or plates which are separated from each other and act as discrete dynodes i.e. dynodes which are sufficiently conductive to maintain all their exposed surfaces at the same potential (in operation a discrete dynode will normally produce only one multiplication in response to the landing of an input particle—this contrasts with the multi-hop operation of conventional continuous-dynode devices). The laminated channel plate structure which is closest to the continuous dynode type is a structure in accordance with Patent Specification No. 1,401,969 (Application No. 53371/71), wherein the matrix is formed as a laminated structure comprising alternate conductor layers and resistive separator layers with aligned apertures providing the channels. Since the separators are resistive, any charge accumulated thereon by the arrival of electrons will flow to the more positive adjacent conductor. Similarly, electrons will flow from the more negative adjacent conductor to replace any secondary electrons emitted from a resistive layer. It is preferable in many cases to modify the laminated structure still further by changing the separator material from a resistive or slightly conductive material to

an insulator as in the arrangement of Burns et al, in which case the provision of an individual d.c. supply for each conductor layer becomes a necessity. In this case the conductor layers provide the entire dynode action and the edges of the separator layers may be set back from the channel apertures so as to be protected from the electron flow in order to prevent the formation of static changes. Furthermore, the first and last conductor dynode layers act also as the input electrode and the output electrode respectively.

Thus far the physical separation of the individual channels has been preserved, but that too can be modified since the insulating separator layers can no longer take part in the secondary-emission and current-supply functions and therefore no longer need to be continuous. Examples of discontinuous separator layers are given in Patent Specification No. 1,402,549 (Co-pending Application No. 59966/71) and these include separators formed as arrays of lines or dots of separator material.

In the Burns et al arrangement and in the examples described in the aforesaid Patent Specifications No. 1,401,969 (53371/71) and No. 1,402,549 (59966/71) the apertures in the conductor layers are of conical form, and an alternative cylindrical form has been described elsewhere. Such known straight-sided configurations are illustrated respectively in Figures 1A and 1B of the diagrammatic drawings accompanying the Provisional Specification. These suffer from penetration of the electric field into each dynode aperture due to the potential applied to the preceding dynode. This results in a retarding field which prevents low-energy (i.e. a few eV) secondary electrons from leaving the wall at the input end of each aperture where they encounter a retarding field (the affected area is indicated schematically at R in Figure 2 of the said drawings). As the majority of secondaries have low emission energies, this effect is significant and some 50% of the wall area can be so affected.

In the case of Figure 1B, as the apertures are wider on the input side the potential of the preceding dynode has even more influence on the field within the hole. This is also true in the case of a dynode aperture configuration of tapered form having curved walls as published by V. Jares and M. Dvorak at pp. 117 et seq of "Advances in Electronics and Electron Physics" (Edited by L. Marton, Vol. 33A, Academic Press, 1972) (the authors have obtained such an arrangement by using a stack of shadow-masks as used for colour T.V. tubes, and this is illustrated in Figure 3 of the said drawings).

The principal object of the present invention is to reduce or overcome this effect of field penetration and the invention is based on the following principle. If incoming electrons can be prevented from landing on the unproductive input region of the wall of each aperture of a discrete dynode, the efficiency can be improved as electrons can then only land on regions where secondaries are accelerated away from the surface. (This assumes that these secondaries land on subsequent dynodes and are not accelerated axially through the hole).

In its first aspect, the invention provides a discrete electrically conductive dynode of perforate sheet form for use in a channel plate of the laminated type said dynode having an array of secondary-emissive electron-multiplier apertures each of which apertures has inner surfaces which when viewed in axial section (as defined) are concave with a degree of peripheral overhang at the input face of the dynode and a degree of constriction at its output face, said concave configuration being such as to provide an internal cross-section (as defined) of the aperture which section has an area greater than the input cross-section of the aperture and also greater than its output cross-section, said input and output cross-sections being coaxial, and said constriction being an output region of gradually tapered form so that its multiplier surfaces are inclined to the axis of the aperture and converge towards each other in the direction of the output face of the dynode (for the purposes of this specification an axial section of an aperture is one which contains the central axis of the aperture and is normal to the faces of the dynode and an internal cross-section is one which is parallel to the dynode faces and lies therebetween).

In such an arrangement the overhang at the input end of an aperture makes it possible to concentrate more of the incoming electrons on the more productive area which lies in the inclined converging output region of the aperture, and the latter area is placed in the path of the electron flow by the inclined converging form of said region.

Advantageously the dynode may be composed of two perforate mating sheets which are bonded together and are electrically conductive and electrically connected to each other.

The input cross-section of each aperture may be equal or approximately equal to its output cross-section, and the apertures may be symmetrical about a median internal cross-sectional plane. The latter features permit a two-part construction wherein the two mating sheets are of equal thickness

and have tapered half-apertures of identical geometrical form.

If the apertures are circular in cross-section, their concave inner surfaces may for example have a substantially spherical or spheroidal form or they may be made up of substantially conical sections as will be explained.

As for relative dimensions, good practical results have been obtained with input and output diameters or widths approximately equal to each other and to the thickness of the dynode.

Since the gain obtainable with a single dynode is low, it is desirable (particularly for imaging applications) to employ a stack of dynodes in cascade to form a channel plate structure of the laminated type. Thus according to a second aspect, the invention provides a channel plate structure of the laminated type comprising a stack of dynodes as defined above in accordance with said first aspect of the invention which dynodes are separated from each other by separator layers and arranged in cascade with aligned apertures providing the channels. The structure also includes preferably an input dynode which has its apertures aligned with those of the other dynodes and has an aperture form which is tapered and opens out in the direction of incoming electrons. In such structures the mutual separation of the dynodes can be effected in accordance with any of the separator arrangements referred to above provided the conductor layers are arranged to provide all, or substantially all, the secondary emission or dynode action. The alignment of the apertures is not necessarily normal to the faces of the plate as will be explained.

Embodiments of the invention will now be described by way of example as applied principally to aperture configurations which have circular cross-sections with input and output diameters equal or approximately equal to each other and to the dynode thickness and have separators of insulating (as opposed to resistive) material. Such embodiments will be described with reference to Figures 4 to 8 of the diagrammatic drawings accompanying the Provisional Specification and Figure 9 of the accompanying diagrammatic drawings, while Figures 10 to 12 of the accompanying drawings show a tilted dynode stack arrangement and illustrate two applications of the invention to imaging tubes.

Dealing first with the individual aperture configuration, Figure 4 shows in axial section a spherical form of aperture which is symmetrical about a median internal cross-sectional plane Pm. For test purposes, single-channel multipliers have been made of such shapes with the input and output diameters d1—d2 each substantially equal to the dynode thickness *t*; the centre of curvature was (because of the symmetry adopted) midway along the axis Xc of the aperture (in this case the axes of the individual apertures coincide with the axis of the whole channel). Large gain increases have been observed from 10-dynode multipliers with dynodes of this form when compared with comparable multipliers having forms such as those of Figures 1A or 1B. The highest gain to date is 10^6 for a 10-stage single-channel test device and over 10^5 for 10-stage arrays of channels.

The concave configuration shown is such that the internal cross-section of the aperture on the plane Pm (diameter d3) has an area greater than the input cross-section of the aperture at the input face (having diameter d1) and also greater than its output cross-section at the output face (diameter d2).

It appears that the radius of curvature *r* and the inter-dynode spacing *s* are not very critical and also that substantial variation of d1 and d2 is tolerable. In particular, it appears that the symmetry d1=d2 is not essential, in other words the origin of the radius *r* does not have to lie half-way along the axis of the aperture.

The concave shape of the aperture is not critical and can be varied in many ways, provided that there is a region of input overhang (O1 in Figures 4 and 9) and a constriction forming an output region of gradually tapered form with inclined gradual convergence of its multiplier surfaces (O2 in Figure 4 and 9).

For example, the radius of curvature in the axial planes may differ from the radius of the maximum cross-section (d3/2) and there may be two different radii of curvature for the input and output halves.

A further variant, the spherical form may be approximated by a series of conical or substantially conical surfaces, and in an extreme case it is possible to use merely two opposed conical surfaces. However, conical surfaces are difficult to obtain and do not appear to offer any advantages over curved profiles.

Yet another variant consists in adopting non-spherical curved forms which can be readily obtained by etching. This is relevant to the question of dynode manufacturing techniques.

A method of manufacturing a dynode according to the invention includes the steps of forming two perforate mating sheets which are electrically conductive and bonding said sheets together with their corresponding holes aligned coaxially so as to form the apertures of the dynode.

Preferably the two mating sheets are half-plates or half-dynodes of equal thickness and have tapered holes of identical geometrical form.

A preferred version of these methods involves chemically etching through exposed and developed patterns in photoresist in a manner well-known in the art, each dynode being made in two parts i.e. from two mating sheets which may be half-plates of equal thickness (a symmetrical example is given in Figure 5 where the composite dynode is divided along the median plane Pm). Exposure and etching of each half can be applied on the one side where the holes have largest area. Dynode materials may be metals having surface treatment for good secondary emission properties in the apertures (e.g. BeCu alloy) or cheap metals such as mild steel coated with secondary emitting aperture surfaces (for example an oxidized BeCu film or an MgO coating).

As a particular example of this process, the two halves of the dynode may be a bonded pair of matched shadow-masks as made for colour T.V. display tubes, and a preferred example is illustrated in Figure 6 as an axial section of the channel. The two mating sheets or half-plates must be held at the same potential during operation (as will be indicated in Figure 7) and this may be ensured by electrical contact through the bond if the latter is suitable. In this arrangement the output half of each aperture has appropriate surface treatment to ensure the requisite secondary-emissive properties and the form of each half is similar to the form shown in Figure 3.

An assembly of dynodes forming a laminated channel plate is shown in Figure 7—8 with channels having axial sections of a form similar to that of Figures 4 (if the dynodes are made from two symmetrical halves as described with reference to Figure 5, then the first dynode M(1) can be constituted by one such half-plate).

Figure 7 is an axial section while Figure 8 is an elevation taken from the line VIII—VIII of Figure 7. The last three stages of the channel plate are shown having metal dynodes M(n—2), M(n—1) and M(n) separated from each other by insulating separator layers D. Since plate M(n) is the last one of the series, it takes the place of the output electrode of a continuous-dynode channel plate. Similarly, there is a first plate M(1) which takes the place of the input electrode of a continuous-dynode channel plate.

In operation all the M plates or dynodes are fed, as shown, with increasing potentials by a tapped D.C. supply source shown schematically at Bm.

A method of manufacturing a channel plate structure according to the invention may include the steps of assembling and bonding together a number of mating pairs of perforate conductive sheets in a stack with perforate insulating separator layers between adjacent pairs of sheets and with the sheet apertures aligned so as to form dynode apertures defining the desired channels.

Broadly such a method can be carried out in either of two ways. According to the first the mating pairs of sheets are bonded together to form dynodes before being assembled with the separator layers to form the stack. However, there are advantages in adopting the second version of this method wherein sub-assemblies are first formed by bonding a first conductive sheet to a second conductive sheet appertaining to an adjacent dynode with an intervening separator layer, and wherein such sub-assemblies are then stacked in mutual alignment and bonded together so that each dynode comprises two sheets derived from separate sub-assemblies.

Turning now to the practical manufacturing details, the stack may, for example, be made from pairs of half-plates with tapered holes by depositing each separator layer on a half plate on that side where the holes have smallest area, but it is undesirable for separator material to be deposited inside the tapered holes. One method of manufacture which avoids this is to apply the separator material in the form of a continuous sheet, and to use the perforate metal half-dynode as a mask through which holes may be etched in the separator. Coating of perforate mild steel half-plates (on one side) with a layer of glass can be done by enamelling or by electrophoresis or by means of a process similar to the Vitta Tape process (Vitta Tape is a product of the Vitta Corporation of America). A glass-loaded adhesive tape is applied over that surface of each half-plate where the holes have smallest area. Each coated half-plate is then heated until the glass takes on a vitreous form. The glass side is then coated with an etch-resist and holes are etched into the glass through the plate apertures, hydrofluoric acid being a possible etchant. After etching, the resist is removed. If sub-assemblies are required in accordance with the second version of the method referred to above, then such a glass-coated half-plate appertaining to one dynode can be secured to (but insulated from) a half-plate appertaining to an adjacent dynode by a process wherein the two half-plates are joined together in registration and heated until the remaining glass melts and bonds them together. While forming a separator layer between them. Such sub-assemblies of half-plates are then

assembled into a stack and the joins between the pairs of mating half-dynodes can be effected e.g. by gold diffusion bonding.

If the material adopted for the conductor layers (e.g. mild steel) is not sufficiently secondary-emissive for a particular application, the secondary-emissive dynode properties of some or all of the conductors can be enhanced by providing a coating of a more emissive material on the appropriate exposed surfaces of the conductors inside the channels.

The glass separator layers D can be etched back by a separate step subsequent to assembly and bonding of the stack of plates. As a result the apertures in D can be greater than the largest cross-section of the metal plate apertures.

Although symmetrical examples have been illustrated in Figures 4 to 8 of the drawings, it has been explained above that it is not necessary for a dynode according to the invention to be symmetrical about the median plane (e.g., the plane Pm of Figures 4 and 5). Accordingly, other structures which are not symmetrical in this sense will now be described by way of example with reference to Figure 9.

In Figure 9 the part M of each metal dynode has apertures of approximately conical form with aperture axes Xa which coincide with the general channel axis Xc. The output region O2 provides the operative multiplying surfaces which are inclined to the axis of the aperture and converge towards each other in the direction of the output face of the dynode. The approximately conical part of each aperture cooperates and mates with a conductive overhanging surface O1 which is also a part of the dynode and is provided as a layer on the adjacent separator D. The layer O1 may be applied to the entire separator on one side, as shown, and this may facilitate manufacture by allowing each separator to be coated completely before the dynode parts M and separators D are assembled as a stack. However, this is not essential from the operational point of view since it is sufficient for each overhanging layer O1 to be in electrical contact with the adjacent M-plate so as to provide therewith the desired concave configuration when viewed in an axial plane. The separators D may be etched back from the edges of the apertures e.g. as shown.

As a variant of the Figure 9 arrangement a straight-sided axial section may be adopted so as to produce a truly conical aperture form to replace the curved profile shown, and the profile in axial section is still concave in that there is a peripheral cavity between the conical wall and the flat overhang O1. However there do not appear to be any clear advantages in doing this and additional manufacturing problems would arise.

In the example of Figure 9 the dimensional proportions of the apertures are the same as those of Figure 4 in the sense that the input and output diameters (d1—d2) are substantially equal to each other and to the dynode thickness t.

Whereas the dynode apertures of the examples illustrated in the drawings have rotational symmetry about their individual axes, it is possible (subject to the requirements of the manufacturing processes) to employ apertures which have non-circular cross-sections, for example square or hexagonal cross-sections. Thus, for example, the arrangements of Figures 4—5 can employ apertures of square cross-section having four cylindrical walls (the axial section shown remains unaltered) and similarly the arrangement of Figure 9 can employ approximately pyramidal apertures of square cross-section. If apertures of square cross-section are thus used, the input and output widths may be approximately equal to each other and to the dynode thickness.

Although described as having continuous separator layers D of insulating material, other arrangements are possible. Thus, for example, the assemblies of Figures 7—8 may have layers D of resistive material and/or said layers may be discontinuous e.g. in the form of arrays of lines or dots in accordance with the aforesaid Patent Specifications No. 1,401,969 (Application 53371/71) and No. 1,402,549 (Application 59966/71).

As aforementioned, the alignment of the apertures does not have to be orthogonal to the faces of the plate. Thus the laminated construction of the matrix permits successive conductor layers to be displaced with respect to each other so as to enable their apertures to form channels which depart from the conventional configuration of straight channels normal to the channel plate faces. This may be done to achieve various effects which have been described earlier in relation to continuous-dynode plates. Thus, for example, the dynodes may be continuously staggered conductor layers arranged to provide channels which are at an acute angle to the normal to the faces of the channel plate (this arrangement can e.g. prevent orthogonal electrons from passing through without collisions and it can also prevent optical and ion feedback from a display screen to a photo-cathode on the input side of the plate). An example of such a construction is shown schematically in Figure 10 where a stack of dynodes is

staggered to tilt the channel axes Xc at an angle α to the normal to the faces. (In this case the tilted axis Xc of a complete channel must be distinguished from the axes Xa of individual apertures which axes are still normal to the faces of the channel plate). In a similar manner variably staggered conductor layers may be arranged to provide curved channels to prevent ion and optical feedback.

Such staggering of the dynodes may reduce their multiplying efficiency, but the gains obtainable are so high that some loss can often be tolerated in the interests of preventing feedback.

Channel plates according to the present invention can incorporate various features which have been described for continuous dynode channel plates. Thus in image intensifier applications it is sometimes desirable to provide a thin layer or membrane across an end (usually the entrance) of each channel, and the following are specific examples:—

(A) The provision of a photo-emissive layer across each channel entrance as described in Patent Specification 1,154,515.

(B) The provision of electron-permeable conductive membranes across the channel entrances as described in Patent Specification 1,175,599.

Channel plates according to the present invention can be used in a variety of imaging tubes, typical examples being display tubes such as image intensifiers and cathode ray tubes. As aforesaid, the invention has particular advantages in applications requiring large-area viewing screens, for example television display applications and X-ray image intensifiers. (In particular, channel plates according to the invention may replace those used in the colour display applications described in Patent Specifications Nos. 1,402,547 and 1,402,548 (Co-pending Application 42723/71)

Figure 11 of the accompanying drawings illustrates schematically the use of channel plates in accordance with the invention in an image intensifier tube of the proximity type. In the example given a channel plate I (which may be as described with reference to any of Figures 4 to 10) is shown inside the envelope of an image intensifier tube containing also a photo-cathode PC and a luninescent screen S. The input and output electrodes of the channel plate are shown at E1 and E2 respectively and an object O is shown imaged on to the photo-cathode. Electrodes E1—E2 correspond to the first and last dynodes of the stack (e.g. M(1) and M(n) of Figure 7). The source Bm has tappings (not shown) so as to supply individual dynodes e.g. as shown in Figure 4 while sources Bo and B2 provide the required potentials for the PC—E1 and E2—S stages.

A second example of an imaging tube is given in Figure 12 which shows a cathode-ray display tube comprising an electron gun G (including a cathode K) for generating a beam *b* which is deflected by means *d* so as to scan a channel plate I constructed in accordance with the invention. The plate I is followed by a luminescent screen S which may be laid on a flat glass window or support W as shown. Alternatively, the screen S may be laid on a curved face-plate F forming part of the envelope, in which case the channel plate I may be correspondingly curved.

In the case of BeCu the dynodes can be made from two dynode halves bonded together using a copper-silver eutectic braze: One half (preferably the input half) is silver plated and both are then clamped together and heated.

WHAT WE CLAIM IS:—

1. A discrete electrically conductive dynode of perforate sheet form for use in a channel plate of the laminated type said dynode having an array of secondary-emissive electron-multiplier apertures each of which apertures has inner surfaces which when viewed in axial section (as defined) are concave with a degree of peripheral overhang at the input face of the dynode and a degree of constriction at its output face, said concave configuration being such as to provide an internal cross-section (as defined) of the aperture which section has an area greater than the input cross-section of the aperture and also greater than its output cross-section said input and output cross-sections being coaxial, and said constriction being an output region of gradually tapered form so that its multiplier surfaces are inclined to the axis of the aperture and converge towards each other in the direction of the output face of the dynode.

2. A dynode as claimed in Claim 1 which dynode is composed of two perforate mating sheets which are bonded together and are electrically conductive and electrically connected to each other.

3. A dynode as claimed in Claim 1 or Claim 2 wherein the input cross-section of each aperture is equal or approximately equal to its output cross-section.

4. A dynode as claimed in any of Claims 1 to 3 wherein the apertures are symmetrical about a medial internal cross-sectional plane.

5. A dynode as claimed in any of Claims 1 to 4 wherein the apertures are circular in cross-section and their concave inner surfaces have a substantially spherical or spheroidal form.

6. A dynode as claimed in Claims 2 to 4 taken in combination or Claims 2 to 5 taken in combination wherein the two mating sheets are of equal thickness and have tapered holes of identical geometrical form.

7. A dynode substantially as described with reference to any of Figures 4 to 6 of the drawings accompanying the Provisional Specification.

8. A dynode substantially as described with reference to Figure 9 of the accompanying drawings.

9. A channel plate structure of the laminated type comprising a stack of dynodes as claimed in any of the preceding Claims which dynodes are separated from each other by separator layers and arranged in cascade with aligned apertures providing the channels.

10. A structure as claimed in Claim 9 wherein the structure includes an input dynode which has its apertures aligned with those of the other dynodes and has an aperture form which is tapered and opens out in the direction of incoming electrons.

11. A channel plate structure substantially as described with reference to Figures 7 and 8 of the drawings accompanying the Provisional Specification.

12. A channel plate structure substantially as described with reference to Figure 9 of the accompanying drawings.

13. A channel plate structure substantially as described with reference to Figure 10 of the accompanying drawings.

14. An image intensifier tube including a photo-cathode, a luminescent display screen and a channel plate structure as claimed in any of Claims 9 to 13 which structure is located between said photo-cathode and said screen.

15. An image intensifier tube including a channel plate structure substantially as described with reference to Figure 11 of the accompanying drawings.

16. A cathode-ray tube including a channel plate structure as claimed in any of Claims 9 to 13, a display screen on the output side of said structure and an electron gun for scanning the input face of said structure.

17. A cathode-ray tube including a channel plate structure substantially as described with reference to Figure 12 of the accompanying drawings.

18. A method of manufacturing a dynode as claimed in Claim 1 which method includes the steps of forming two perforate mating sheets which are electrically conductive and bonding said sheets together with their corresponding holes aligned coaxially so as to form the apertures of the dynode.

19. A method as claimed in Claim 18 wherein the two mating sheets are half-plates of equal thickness and have tapered holes of identical geometrical form.

20. A method of manufacturing a dynode as claimed in Claim 1 substantially as described.

21. A method of manufacturing a channel plate structure as claimed in Claim 9 including the steps of assembling and bonding together a number of mating pairs of perforate conductive sheets in a stack with perforate insulating separator layers between adjacent pairs of sheets and with the sheet apertures aligned so as to form dynode apertures defining the desired channels.

22. A method as claimed in Claim 21 wherein the mating pairs of sheets are bonded together to form dynodes before being assembled with the separator layers to form the stack.

23. A method as claimed in Claim 21 wherein sub-assemblies are first formed by bonding a first conductive sheet to a second conductive sheet appertaining to an adjacent dynode with an intervening separator layer, and wherein such sub-assemblies are then stacked in mutual alignment and bonded together so that each dynode comprises two sheets derived from separate sub-assemblies.

24. A method of manufacturing a laminated channel plate structure as claimed in Claim 9 substantially as described.

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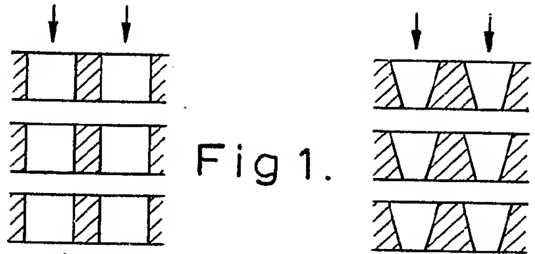


Fig 1.

(A) (B)

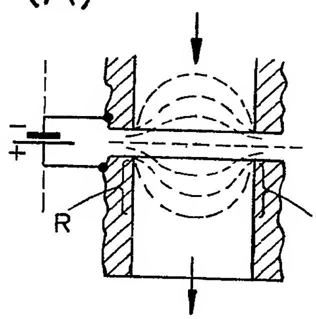


Fig.2.

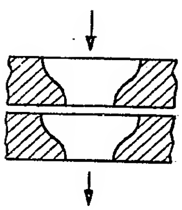
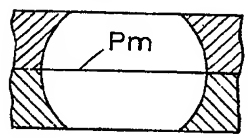


Fig.3.

Fig.5.



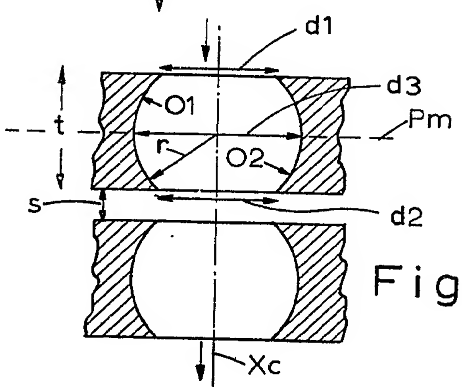
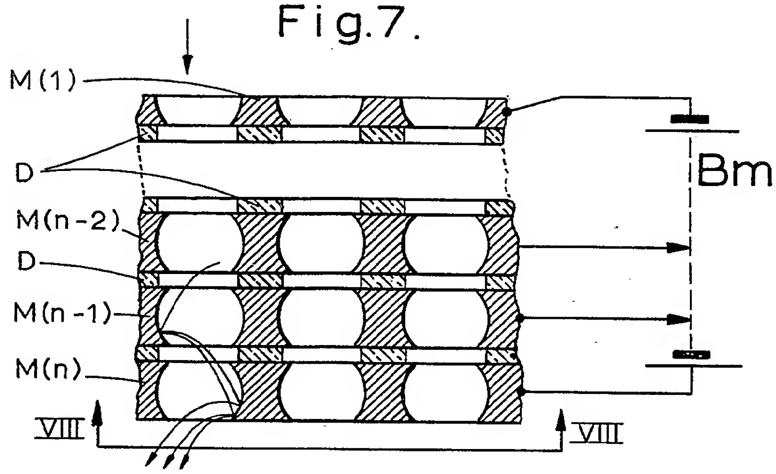


Fig.4.

Fig.6.

Fig.7.



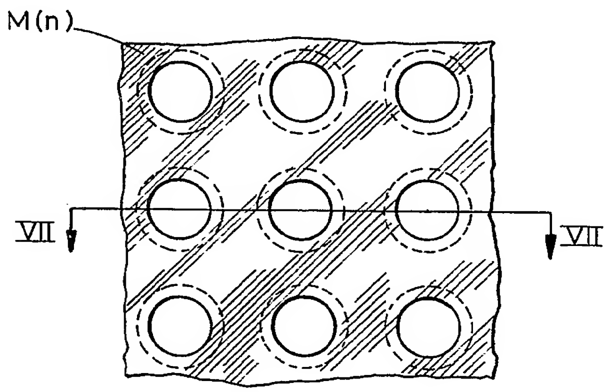


Fig.8.

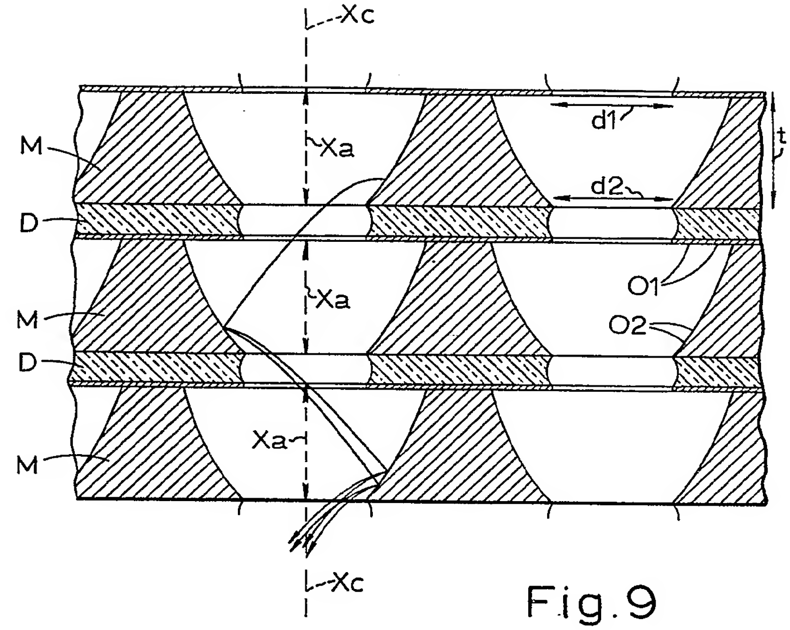
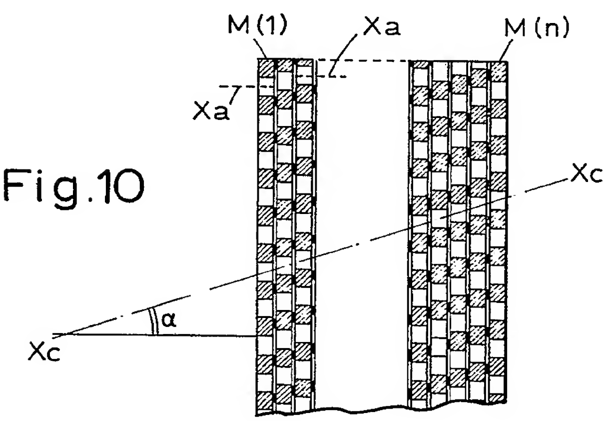


Fig.9

Fig.10



1434053 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

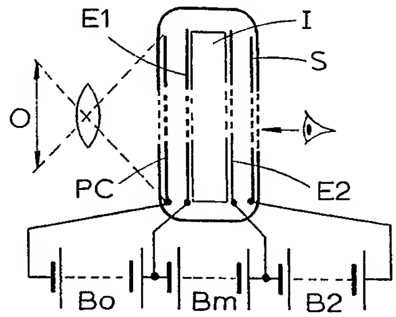


Fig.11

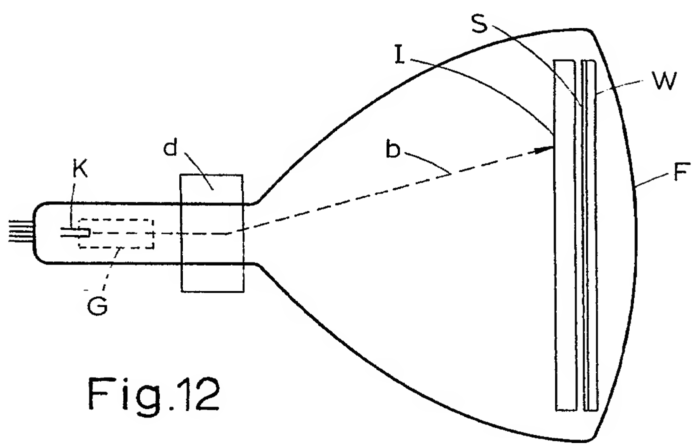


Fig.12